Soldering & Desoldering Feature:

Metcal systems use RF skin effect

Most of the latest generation of soldering and desoldering systems use a separate sensor to sense and control the operating tip temperature. However with the innovative technology developed by Metcal Inc, the heating element itself senses and regulates its own temperature automatically.

Founded in 1982 and headquartered in Menlo Park, California, Metcal Inc is the inventor and developer of an innovative technology in the area of resistance heating. The technology has been named *Self-Regulating Skin Effect*, to distinguish it from other kinds of electrical resistance heating.

By virtue of their metallurgical composition, soldering iron heaters using this technology have the ability to inherently self-sense and self-control heat generation, in order to provide constant temperature. They are designed to maintain and vary their power input (and hence thermal output) to accommodate each thermal demand.

Using this technology products can be developed to operate at uniform, stable design temperatures without reliance on external monitoring and control circuitry. Reliability is increased and the problems associated with inadequate heating or runaway temperatures are eliminated.

Metcal's heating technology results from the combination of two unrelated laws of physics, together with some clever mechanical design. One of these physical laws describes the phenomenon known as *skin effect*; the other describes a characteristic of magnetic materials, called the *Curie effect*.

Skin effect

It is well known that alternating currents, particularly at higher frequencies, tend to concentrate near the surface of a metal conductor. This is due to the interaction between the currents and the magnetic fields produced by them, and is called the *skin effect*.

What happens is that the current density in the conductor decreases exponentially, moving inwards from the conductor surface. The 'skin depth' is defined as that depth which carries 63% of the total current, and is given by:

$$s = 0.503 \times 10^{-2} \sqrt{\rho/(f.\mu)}$$

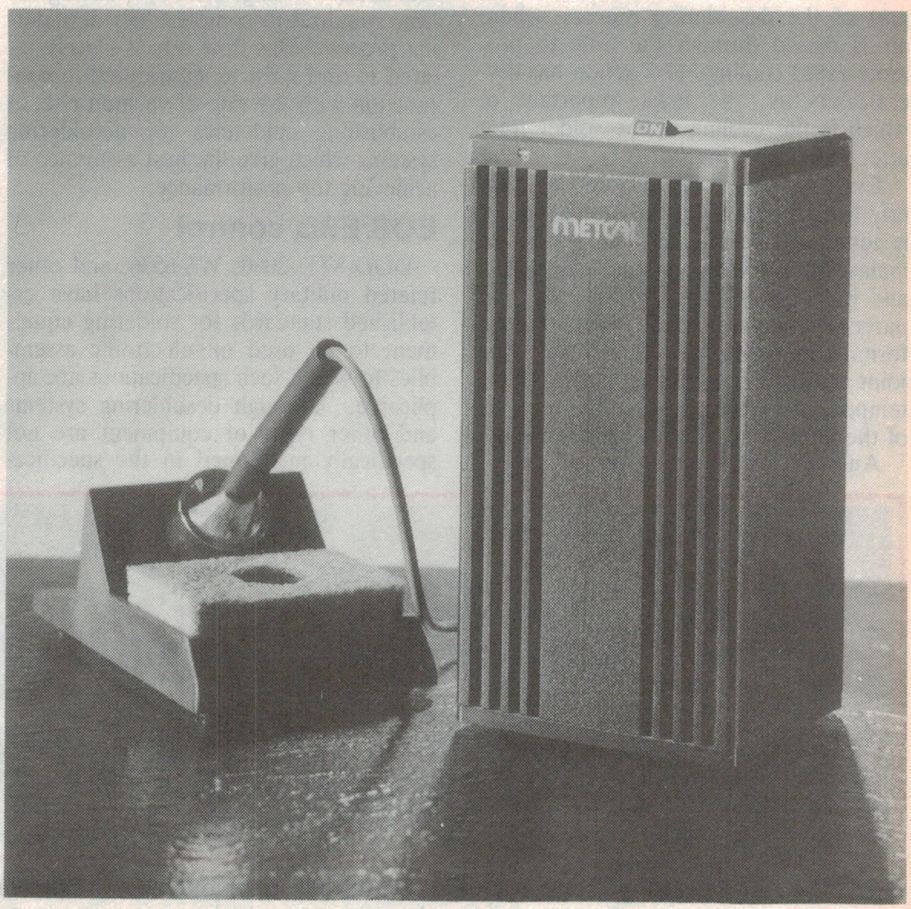
where ρ = the conductor's resistivity, in micro-ohm centimetres;
f = the frequency in MHz;
and μ = the conductor's relative magnetic permeability

You can see from this that the skin depth *increases* with *decreasing* permeability.

Curie effect

Basically, the Curie effect is a phenomenon whereby the magnetic permeability of a material that is 'magnetic' at normal temperatures falls with increasing temperature, reaching unity at a particular temperature – known as that material's *Curie point*. In other words, the material loses its magnetic properties.

Metcal makes use of both skin effect and Curie effect in a way which causes the resistance of the iron's 'heater', formed from a laminate of two metallic



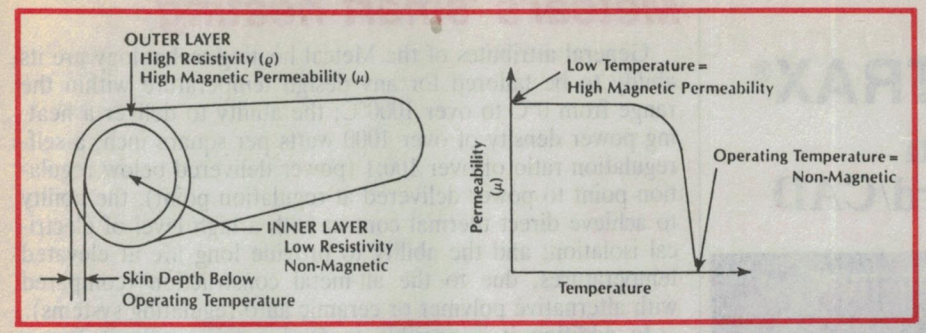


Fig.1: The two layer heater.

Fig.2: Permeability/temp. curve.

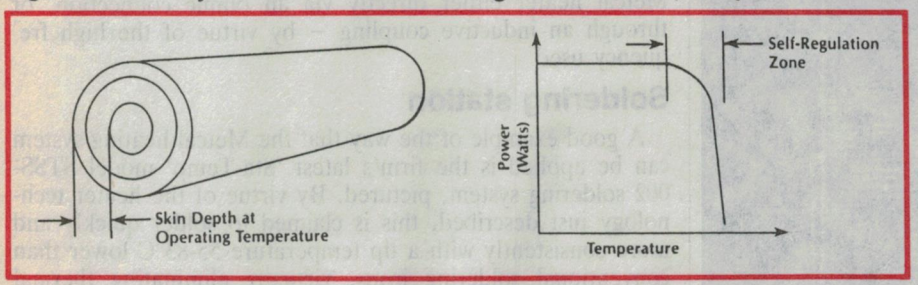


Fig.3: Skin depth in operation.

Fig.4: Power varies with temperature.

layers (Fig.1), to decrease dramatically as its temperature gets close to the Curie point of the magnetic outer layer. This outer layer is a ferromagnetic material with relatively high electrical resistance, while the inner core is a non-magnetic material with low thermal and electrical resistance.

Instead of 50Hz or 100Hz power the Metcal power source provides a high frequency AC, from what is effectively a constant-current source. The high frequency current flows near the surface of the laminate, due to the skin effect.

When the heater is operating below its operating temperature, the skin effect causes most of the current to flow in the outer, high permeability layer. Since this layer also has a high electrical resistance, this causes a high power dissipation and the generation of considerable heat. However as the temperature rises (Fig.2), the magnetic permeability of the outer layer falls due to the Curie effect, which deepens the 'skin' and allows more and more of the current to flow through the low resistance inner layer. This in turn lowers the power dissipation, and with it the heat generated (Fig.3).

At the design temperature, the heat generated and the heat required to maintain tip temperature are in balance, and the temperature is maintained within 1.1°C. When the temperature of the tip assembly is lowered by a thermal load, the heat generation instantly increases to maintain the temperature (Fig.4).

This process is inherently reversible, and provides what is claimed to be the industry's first high power, precision, self-regulating temperature source – what Metcal calls its 'smart heat' technology, with envisaged uses in many fields apart from soldering and desoldering. ▷

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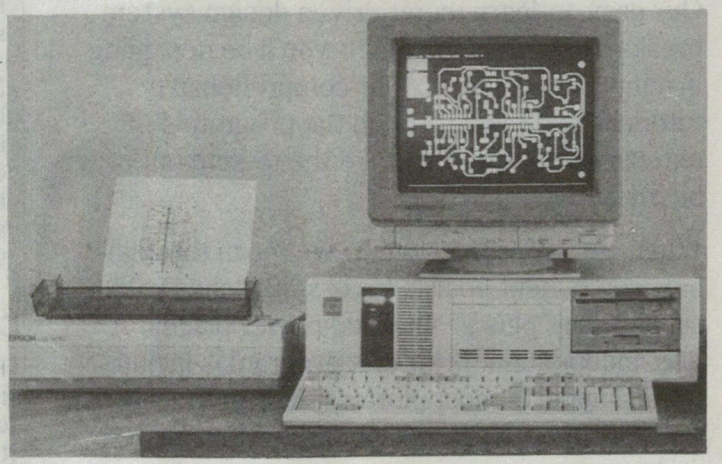

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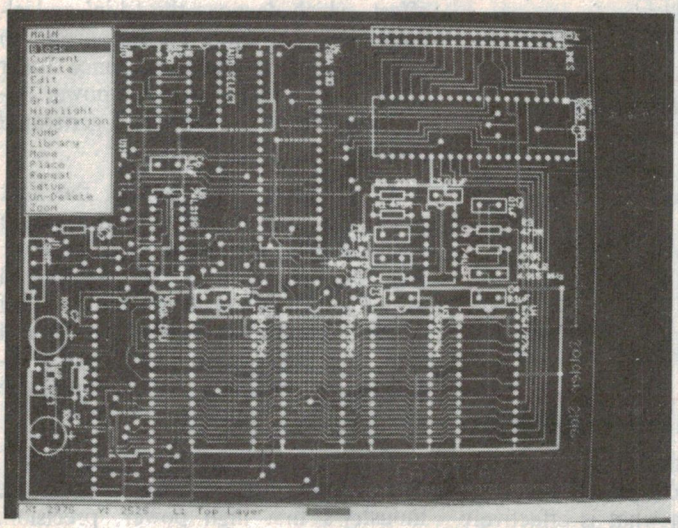

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Metcal's 'smart heating'

General attributes of the Metcal heating technology are its ability to be tailored for any design temperature within the range from 0°C to over 1000°C; the ability to deliver a heating power density of over 1000 watts per square inch; a self-regulation ratio of over 100:1 (power delivered below regulation point to power delivered at regulation point); the ability to achieve direct thermal contact with a high level of electrical isolation; and the ability to provide long life at elevated temperatures, due to the all-metal construction (compared with alternative polymer or ceramic auto-regulating systems).

In addition it is possible to feed heating current into a Metcal heater either directly via an ohmic connection, or through an inductive coupling – by virtue of the high frequency used.

Soldering station

A good example of the way that the Metcal heating system can be applied is the firm's latest 'Sta-Temp' model STSS-002 soldering system, pictured. By virtue of the heater technology just described, this is claimed to solder quickly and more consistently with a tip temperature 55-83°C lower than conventional soldering irons, virtually eliminating thermal damage while at the same time producing high quality soldered connections. As a result, Metcal recommends the use of tips which operate at 100°F (55°C) lower than you would normally choose for a conventional iron.

The system can use a wide range of interchangeable tip cartridges, which can be exchanged in about 2 seconds. The cartridges provide a wide variety of tip shapes, operating temperature ranges and sizes for specific applications, and include utility models, heavy-duty models, long-reach high-powered models, precision models and rework tips for surface mount applications. All tips meet DOD-STD 2000-1B specifications for tip-to-ground millivolts, tip temperature stability and tip-to-ground resistance.

The tip cartridges are designed for efficient and rapid delivery of thermal power, rather than for its storage. This allows the heater to react to the thermal requirements of making the solder connection quickly, bringing the joint to the chosen temperature in the shortest possible time. And the heater within each tip is self-regulating, so the temperature and rate of power delivery are determined by the tip cartridge itself, not by the operator.

The cartridges provide 'start-up' power dissipation figures of 18-35W for precision models, 25-35W for the 600°F 'Turbo' models and 32-38W for the 700°F 'Turbo' models. Heat-up time is specified as 20 seconds, with average tip temperature drop when performing 10 solder connections during a timed test given as 95°F and average tip temperature recovery during the same test 92°F. Time to return to idling temperature after 10 connections is 4 seconds.

The STSS-002 soldering system consists of two main parts – a conventional-looking soldering station and a high frequency constant current power supply, housed in a finned rectangular case. Maximum power output of the supply unit is 40W at nominal line voltage, and 25W into a 50-ohm load.

Other Metcal soldering systems have been developed in the USA, including a model STSS-002 'Solder Signature' system with enhanced features and a model STSS-DS1 desoldering system. These are expected to be available here either later this year, or early in 1990.

Further details of the Metcal 'smart heating' system and 'Sta-Temp' STSS-002 soldering system are available from Australian distributor CLC Agencies, of 51 Armitree Street, Kingsgrove 2208 or phone (02) 750 4005.

Introducing

METCAL

The First Innovation in Hand Soldering In 30 Years

OVERVIEW
Metcal's STA-TEMP Soldering System eliminates the defects which can occur during hand-soldering. Because the STA-TEMP System solders quickly and more consistently at 600°F than conventional irons do at 750°F and higher, it prevents thermal damage and cold solder joints.

GENERAL DESCRIPTION
Each STA-TEMP tip cartridge contains a small, powerful heater which has been designed into the tip itself. This configuration allows the heater to respond directly to the connection by delivering power on demand. Each METCAL heater is self regulating, so it delivers just the right amount of power to bring the connection to the optimum temperature. Direct POWER, not high temperature, gets the job done.

***Eliminates Lifted Pads, Board Measling, Overheated Components**

***Eliminates Electrical Damage**
The STA-TEMP System is fully shielded and grounded.

***Needs No Calibration**
The tip regulates its own temperature. The system needs no calibration to ensure compliance with design specifications.

***Exceeds Military Specification Requirements:**

MIL-STD-2000
MIL-STD-45743E
WS-6536D and E
DOD-STD-1686 CLASS I

***UL Listed and FCC Approved**

Fig.1

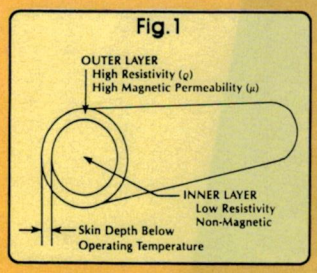


Fig.2

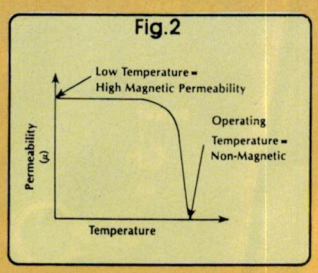


Fig.3

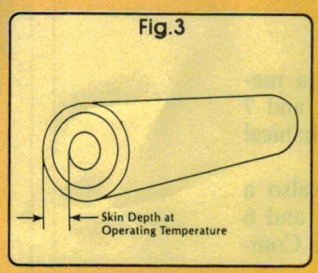
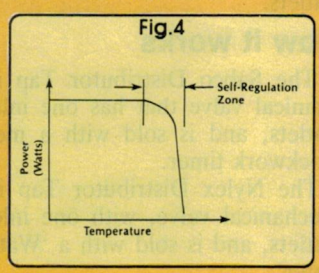


Fig.4



HOW DOES IT WORK?
The "heater" is a laminate of two metallic layers. The outer is a magnetically permeable material with relatively high electrical resistance, the inner a non-magnetic material with low thermal and electrical resistance. The power source supplies a high frequency alternating current which flows near the surface of the laminate due to the "skin effect" phenomenom. When the heater temperature is below its operating temperature, this skin effect causes most of the current to flow in the outer, high permeably layer. **(fig.1)**. Since this layer also has a relatively high resistance, considerable heat is generated by the current. As the temperature increases **(fig.2)**, the magnetic permeability decreases (due to the Curie phenomenom) allowing most of the current to flow through the low resistance inner layer, thus dramatically reducing resistance and heat generation **(fig.3)**. At the design temperature, heat generated and heat used by the tip are in balance and the temperature is maintained at ±2°F. When the temperature of the self-heating tip assembly is reduced by a thermal load, heat generation instantly increases to maintain temperature **(fig.4)**. This process is inherently reversible and provides the industry's first high power, precision, self regulating temperature source.

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